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# Injection capabilities of xanthan gum for soil grouting

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## ABSTRACT

Conventional methods of soil improvement, such as the use of cement, has been linked with various environmental hazards. In recent years, the development of sustainable alternatives to soil improvement has been conducted in numerous studies. Among such is the use of biopolymers in soil improvement. Biopolymers have been shown to be capable of improving the soil strength with decreasing permeability. However, the methods of implementation into the field have not been widely studied. This study focuses on the grouting capabilities of biopolymers and its possible implementation in the field.

## 1. INTRODUCTION

The use of conventional construction materials such as cement and asphalt have been shown to have detrimental side effects on our environment (Worrell, Price et al. 2001, Benhelal, Zahedi et al. 2013). As a result, eco-friendly alternatives have been studied in recent years. Among such alternative, the use of biopolymers has shown that it is capable of enhancing the strength of the soils (Chang, Im et al. 2015) and reducing the permeability in soils (Chang and Cho 2018). As biopolymers are naturally occurring polymers, it is a sustainable material that has been used in numerous industries (Blanshard and Mitchell 1979, Cha and Chinnan 2004, Markarian 2008). However, its use in geotechnical engineering has not been fully developed, and although its potential use has shown promise, the method of implementation has not been widely studied. As such, this paper focuses on the injection capabilities of xanthan gum biopolymer for grouting purposes.

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## 2. EXPERIMENTAL PROGRAM

### 2.1 Xanthan gum

For this study, xanthan gum is used as the main biopolymer focus. Xanthan gum is a polysaccharide biopolymer that is widely used as a food additive. It has pseudo plastic characteristics (Casas, Santos et al. 2000) and is capable of greatly increasing the viscosity of a fluid. As increased biopolymer concentrations result in increased fluid viscosities (Fig. 1) the effects of injection will be highly dependent on the biopolymer concentration.

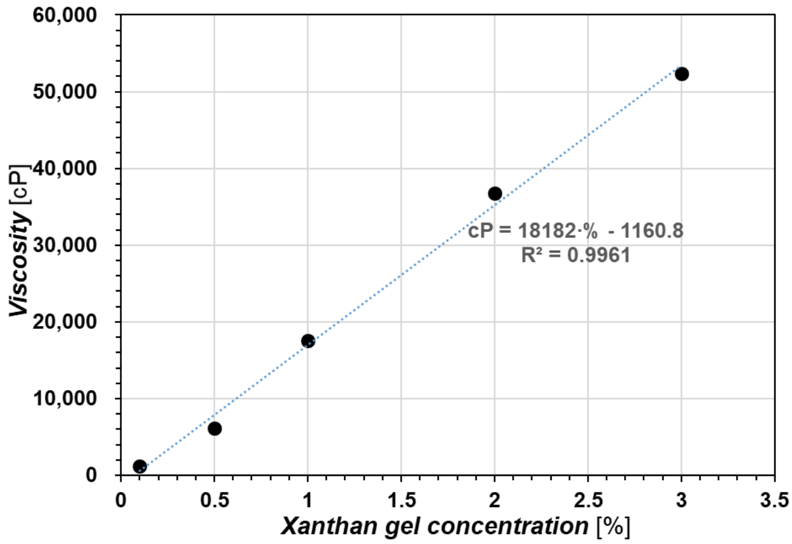


Fig. 1 Increase in viscosity with increase in xanthan gum concentration

### 2.2 Jumunjin Sand

Jumunjin sand is a standard sand used in S. Korea, and it is classified as a poorly graded sand (SP). It has a $D_{50}$ of 1.0 mm with a $e_{min}$ and $e_{max}$ of 0.64 and 0.89 respectively.

### 2.3 Experimental Setup

The injection tests were carried out under 2 cases; 1) laminar flow and 2) in soil mass. In the case of laminar flow (Fig. 2a) an air compressor was used to push the biopolymer solution through a thin spacing. Tests were performed at varying air pressures (0.2, 0.4, 0.6 MPa), opening size (t) (0.25, 0.5, 0.75 mm), and biopolymer concentrations (0.5, 1.0, 2.0% to water). In the case of injection into the soil mass (Fig. 2b) a needle was used to inject the biopolymer into the soil mass. The injection was carried out at varying injection pressures (50, 100, 200, 300, 400 kPa) for 10 min and the volume of the treated soil mass was measured.

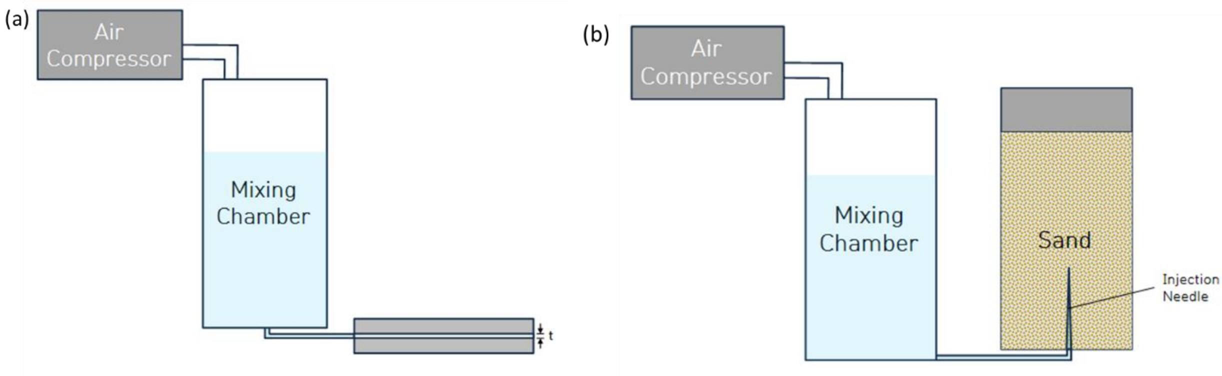


Fig. 2 Experimental Design of (a) laminar flow (b) into soil mass

## 3. RESULTS AND ANALYSIS

Fig. 3 shows the different flow rates at the different conditions. As expected it can be seen that the higher the biopolymer concentration the lower the flow rate. It was also noted the injection pressures had a larger impact on the solutions with a lower biopolymer concentration. The overall behavior of the flowrate showed a linear response to the increase in the injection pressure.

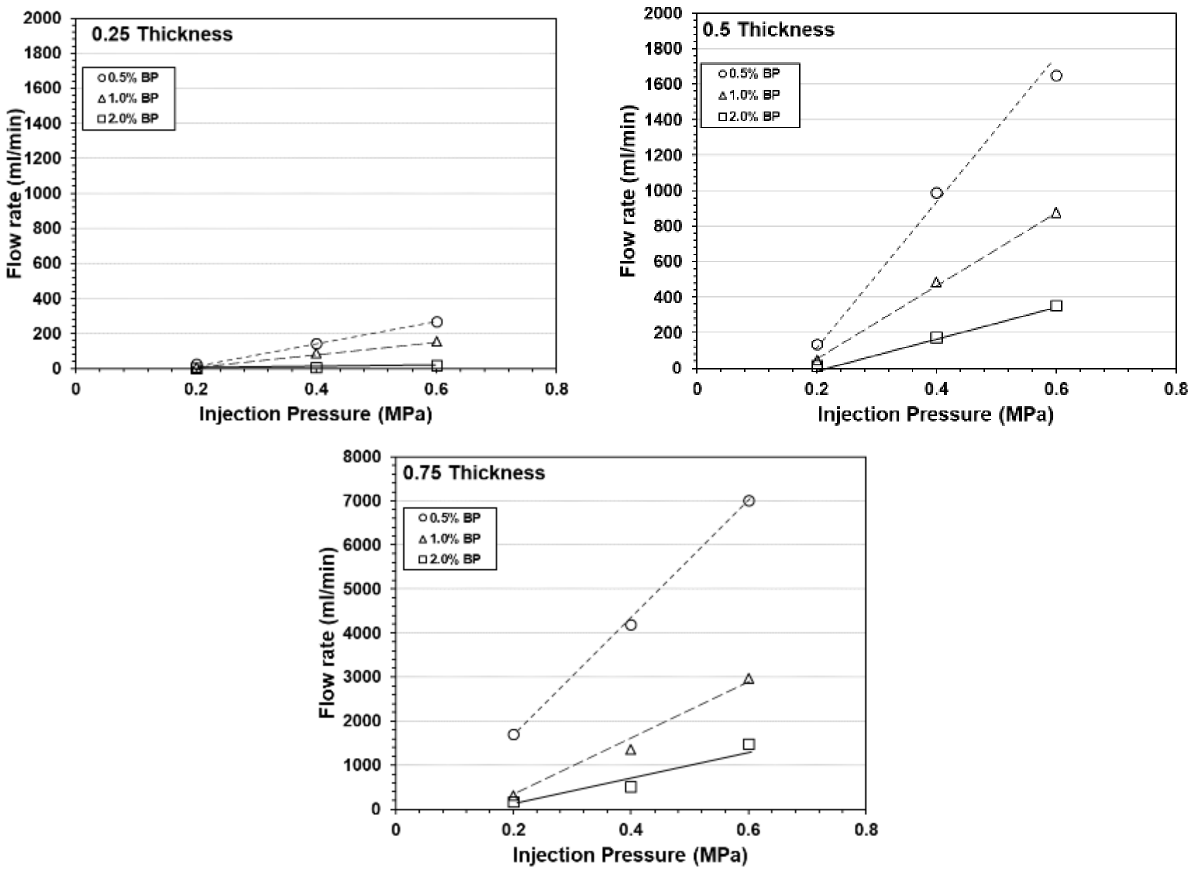


Fig. 3 Injection performance of Xanthan gum in laminar flow

In Fig. 4 the injection performance of xanthan gum into sand can be observed. It was noted that in the case of injection into a bulk volume, the increase in injection pressure did not correlate to a linear increase and instead the volume of treated soil had a tendency to level off.

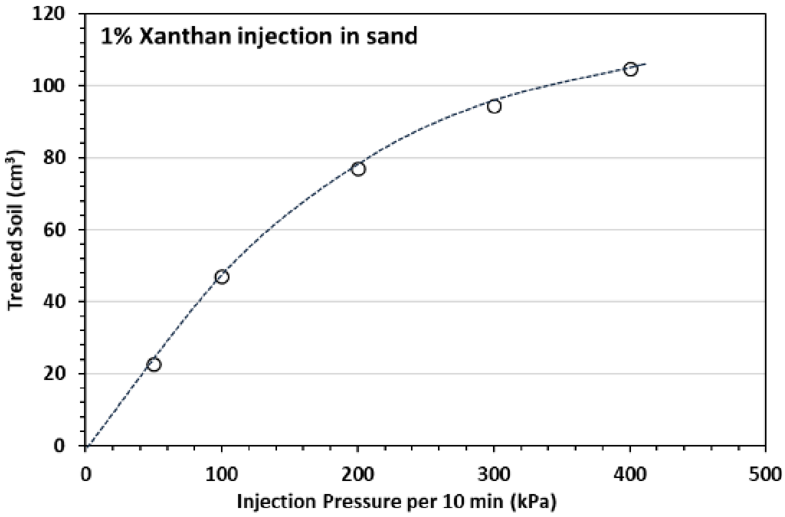


Fig. 4 Injection performance of 1% Xanthan gum into sand

## 4. CONCLUSIONS

The performance of Xanthan gum with injection is greatly limited by the large increase in viscosity of the fluid. Results showed that although the injection is capable of being performed, its efficiency is greatly hindered by an increase in biopolymer concentration. With biopolymer injection into a soil mass its performance efficiency reduces with an increase in the injection pressure. For performance efficiencies, significantly larger injection pressures will be needed for biopolymer than conventional grouting methods.

## ACKNOWLEDGMENTS

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